The Use of Supply Chain Management to Increase Exports of Agricultural Products

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Contents

List of Figures

List of Tables

Executive Summary

The changing composition of U.S. agricultural exports requires changes in the competitive thinking of U.S. agricultural exporters. Twenty-five years ago, bulk commodities–grains, oilseeds, and cotton–accounted for more than two-thirds of U.S. exports. Presently, animal, horticultural, intermediates, and other nonbulk commodities constitute two-thirds of all agricultural exports.

With value-added products, it is difficult for an agricultural export firm, by itself, to increase its competitiveness and profitability. Consequently, those firms should look for new strategies to succeed. A lower price, while important, is no longer a sufficient strategy by itself to guarantee profitability and success for exporters. Customers are looking for factors such as speed in delivery, product quality, consistency, and innovation.

Exporters require new thinking, strategies, and techniques to meet the sophisticated requirements of international customers. Agricultural exporters need to look for ways to integrate their businesses with other businesses. This report investigates the use of supply chain management (SCM) as a possible strategy to enhance the competitiveness of the agricultural sector in today's competitive environment.

Although the use of SCM as a competitive strategy has existed for several decades, its application for agricultural exports has been very limited, in large part because of the unique challenges that exist in the agricultural export supply chain. One of the significant challenges for

the supply chain for agricultural exports is that the chain is both production and consumer driven. As a result, the successful use of SCM in agriculture requires chain members to recognize and identify areas of shared risks so that those risks–either from a production or a consumer perspective–may be reduced.

The use of SCM by four agricultural firms was investigated. All of the firms were fully aware of SCM. Although their definitions of SCM varied, the increasing importance of SCM was recognized at the staff level. However, only one firm viewed SCM as a competitive strategy. The other firms tended to look at improvements in the supply chain primarily as a means of reducing costs within the company with little recognition of the importance of working with other companies in the supply chain.

Two examples of techniques firms may use to improve their supply chain efficiency are discussed in this report. One example describes a method to improve decision making when more than one firm in a chain is affected by the decision. The other example describes a technique to determine port selection for exports.

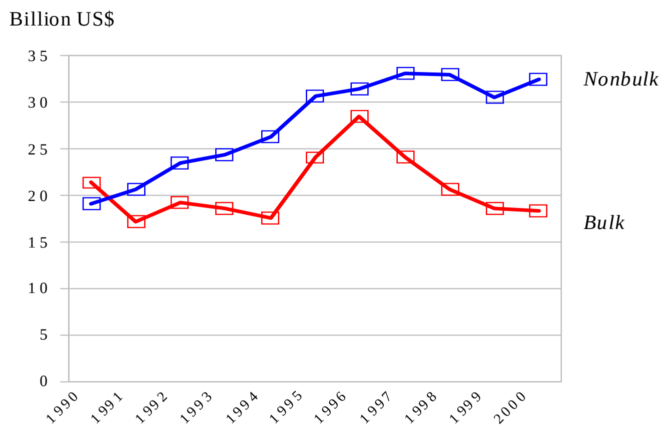
Because of a historical reliance on low price as a competitive strategy, most agricultural firms look at cost reduction as the primary driver for this competitive strategy. However, increasingly, customers look for reasons, in addition to a low price, to purchase agricultural products. Consequently, product purchase criteria often include delivery parameters or unique quality characteristics that the current export marketing system does not recognize. With the long history of looking only to price as a competitive factor, the sector of American agriculture dealing with exports may find itself facing new competitive challenges that require a broader strategy then simply the lowest price.

Chapter One: Supply Chain Management and the Changing Agricultural Export Sector

It is well recognized that world markets are changing. They are changing rapidly and at an increasing rate. Markets are becoming more global; customers are becoming more demanding–regarding both price and quality. In addition, product life cycles have shortened with a resulting demand for new and different food products. These changes create an intensely competitive environment for all businesses. Although these changes have been identified, strategies by which a business can profitably respond to these changes are less well recognized. One strategy that has received considerable attention over the past decade–and gained further momentum with recent improvements in transportation and information technology–is supply chain management (SCM).

The Changing Composition of U.S. Food and Agricultural Trade

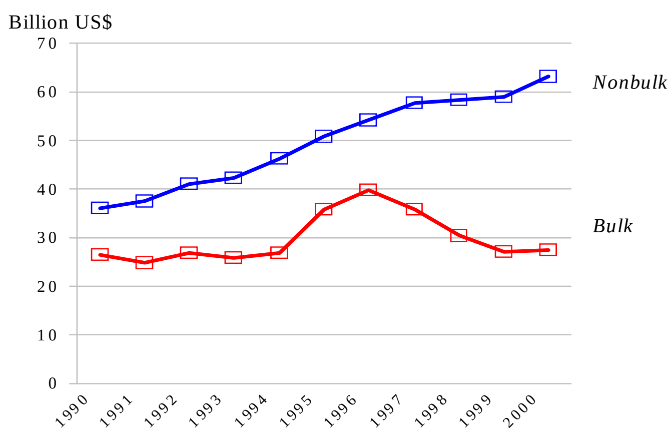
The changing composition of U.S. food and agricultural trade is one of the unmistakable trends of the last two decades. Twenty-five years ago bulk commodities–grains, oilseeds, and cotton–accounted for more than two-thirds of our exports. Now, animal, horticultural, intermediates, and other nonbulk commodities make up that two-third's of exports (figure 1).



Source: *FATUS; fiscal years*

Figure 1. U.S. nonbulk exports surpass bulk in 1991

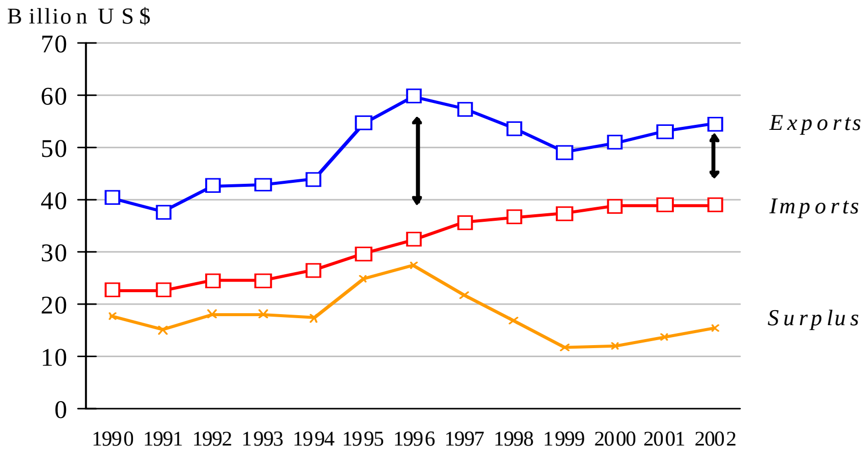
The same change in trade composition from bulk to nonbulk products has occurred with U.S. imports (figure 2).



Source: *FATUS; fiscal years*

Figure 2. Adding imports to exports, nonbulk trade twice the value of bulk

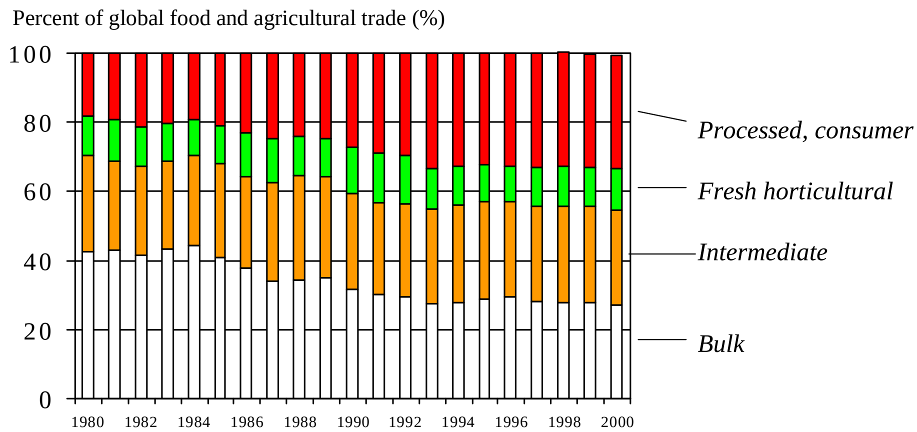
If added together, nonbulks now are more than twice the value of U.S. bulk trade. (Bulk is defined as grain, oilseeds, cotton, sugar, rubber, and other agricultural raw materials). Further, imports of agricultural products are becoming relatively more important (figure 3).



Source: *Outlook for U.S. Agricultural Trade*, Nov. 30, 2001
Data are projected for 2002.

Figure 3. U.S. agricultural trade surplus narrows

This change in bulk and nonbulk export trade is not limited to the United States. Worldwide trade reflects a similar change (figure 4).



Source: UN COMTRADE

Figure 4. Rising share of nonbulk commodities worldwide

Some of these changes are a result of macroeconomic factors. However it is believed the major factor is the development of a U.S. food system that demands greater variety and stable year-round supplies.

U.S. exports are concentrated in the high- and middle-income markets of the European Union (EU), Canada and Mexico (North American Free Trade Area–NAFTA), and East Asia. These three areas are economically large (80 percent of the global economy) and account for a very significant share of U.S. agricultural exports (figure 5).

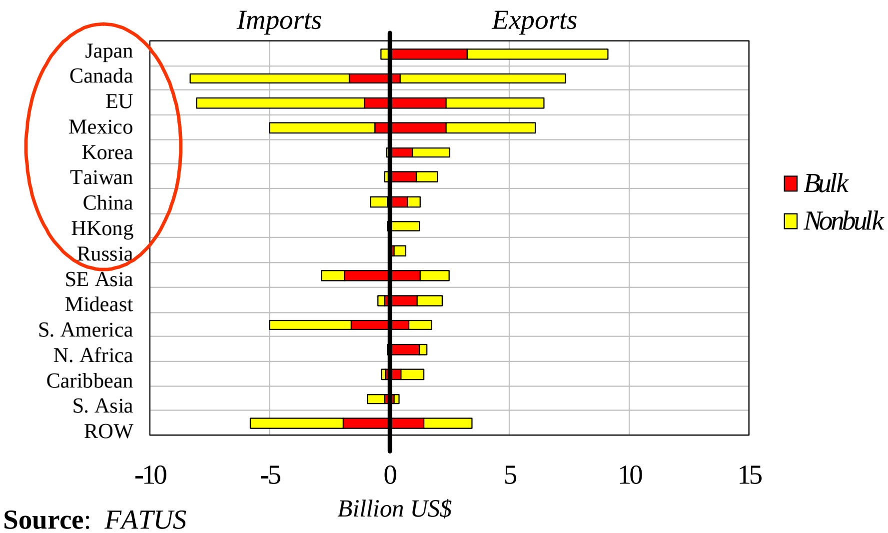
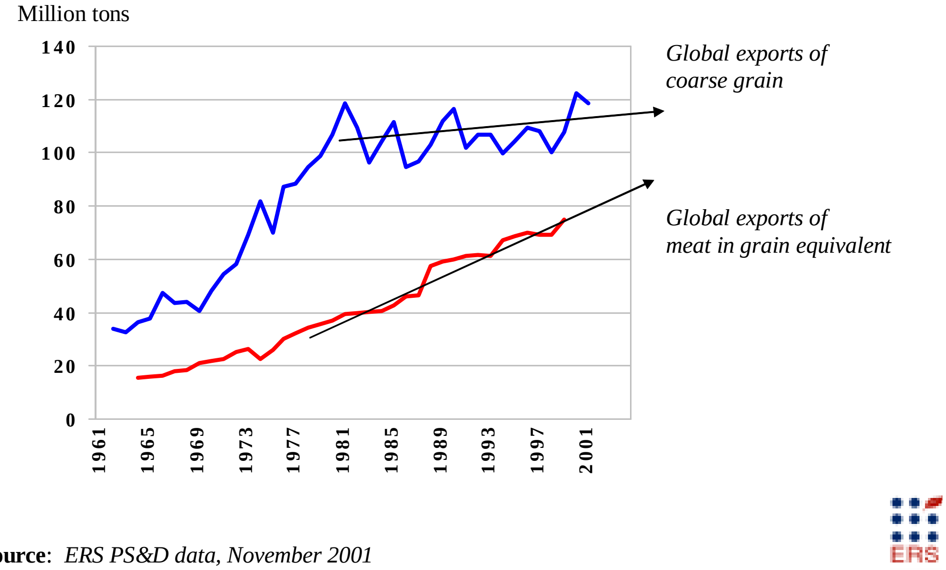


Figure 5. U.S. food and agricultural trade balances, 1999-2000

Nonbulk exports from the United States are even more concentrated in these three markets. U.S. trade with these regions has been large (80 percent) and remarkably stable despite of the destinations being classified as "emerging markets." The real emerging markets are best described as ones emerging within these large middle-income and developed markets. An important reason why the EU, NAFTA, and East Asia are big and growing markets for nonbulk products is that in most cases, they have the established infrastructure to accommodate this trade. An important aspect of the shift in trade composition has been the rise of trade in meats and the stabilizing of trade in coarse grain. This has happened globally and is also reflected in U.S. trade (figure 6).

There are at least four factors that have contributed to this shift in trade composition:



Source: *ERS PS&D data, November 2001*

Figure 6. Exports of meat in grain equivalents up, coarse grain trade stable

First, and probably most important, is income growth and its effect on diet. Economic growth and higher income levels lead to the upgrading of diets. A shift in preferences from grain-based diets to diets that are more diverse and feature meats, fruits, and vegetables has been observed around the world. Increased income also leads to a shift in the locus of food preparation away from the household, leading to consumption of foods that are more processed and to an increase in away-from-home dining. These changes, when combined, also sharpen the demand for year-round supplies for products that were previously only available locally at certain, limited times during the year (figure 7).

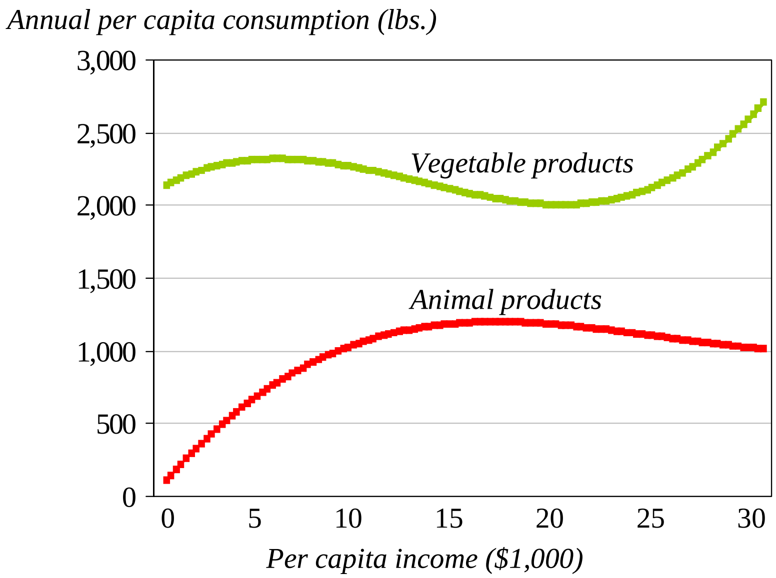


Figure 7. The composition of the diet varies with income

Second and third, the demand for a more diverse diet has been driven by income growth, but **policy reform** and the **freer play of comparative advantage** help determine the supply of many of these food products. When Japan liberalized its beef market over 10 years ago, Japanese beef production declined, and imports from the United States, Australia, and other sources increased to meet growing Japanese demand (figure 8).

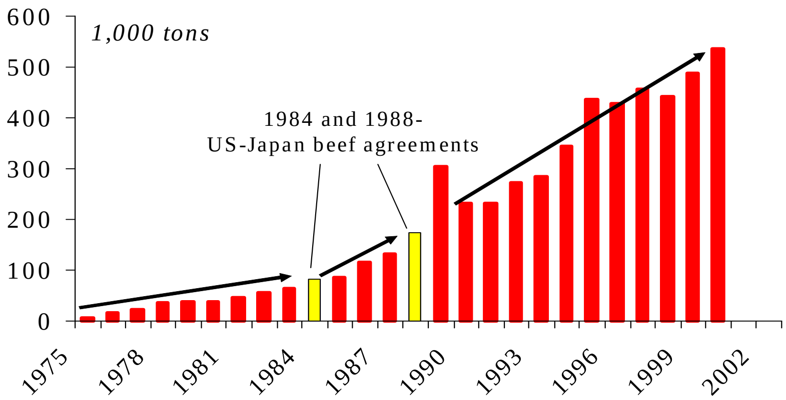


Figure 8. Market-opening measures expand U.S. beef exports to East Asia

Abundant U.S. supplies of low-cost feed and roughage made it difficult for Japanese beef producers, once protected by import quota restrictions but now protected by relatively modest tariffs, to compete with Japan's high land and feed costs. With the increase in U.S. exports of beef to several destinations, primarily Japan, U.S. exports of feed grain have leveled off as a result of a decline in livestock feeding in Japan. Thus, Japan's policy adjustment and the U.S. response have led to change in our bilateral agricultural trade with Japan: a substitution of the value-added product, meat, for the bulk product, feed grain.

Consequence of the Change in Export Characteristics

With the growth of agricultural exports in nonbulk areas, the ability of American agriculture to meet customer expectations becomes the key competitive factor. Fungible commodities–i.e., bulk commodities–rely primarily on price as a competitive tool. Value-added exports rely on a series of processes, from the farm to the final consumer, to assure a product exported meets the buyers' expectations and is competitive. The series of companies involved in providing the product demanded and the relationships of those companies are called a supply chain.

In a typical supply chain raw materials are purchased from a variety of sources, items are produced at one or more factories and shipped to warehouses for intermediate storage, and, finally, items are shipped to retailers or customers. Consequently, to reduce cost and improve service levels, effective supply chain strategies must take into account the interactions that take place at various stages in the supply chain. The supply chain, which is also referred to as the *logistics network*, consists of suppliers, manufacturing centers, warehouses, distribution centers, and retail outlets, as well as raw materials, work-in-process inventory, and final products.

Supply Chain Management as a Competitive Response

The shift in the nature of U.S. exports from bulk to value-added has resulted in more steps added to the supply chain for exports. These steps involve, not only increased processing, but an increase in the number of firms involved in making a product available for sale to the final overseas consumer.

The increase in the steps or links in a supply chain has made it difficult for a firm, by itself, to increase its competitiveness and profitability. Consequently, firms are now looking for new strategies to succeed. A lower price, while important, is no longer, by itself, a strategy sufficient to guarantee profitability and success. Rather than trying to compete alone, some businesses have realized that competitive advantages may be gained through business integration. Those businesses have started to look for useful techniques to integrate their businesses with other businesses. As a result of the interest in integrating business, physical distribution management, which includes warehousing and transportation issues, has been integrated with manufacturing, procurement, and order processing. This is the logistics stage of integration. Natural requirements for successful logistics integration include business decisions which take into consideration both suppliers (supply) and customers (demand). It is at this point of integrating a company's logistics that SCM, as a branch of management science and a dynamic form of competitive strategy, takes on importance.

Supply Chain Management Defined

People often use the same terminology to mean different things. SCM is a good example of this situation. There are a large number of sources of information and applied software concerned with SCM issues. Each source of information usually gives its own unique definition of SCM.

This report uses the definition of SCM developed by members of The International Centre for Competitive Excellence (1994):

> *"Supply chain management is the integration of business processes from end user through the original suppliers that provide products, services and information that add value for customers."*

Unique Characteristics of the Management of the Supply Chain

SCM as a management approach has several unique characteristics that distinguish it from other management disciplines, such as operations management, distribution management, material management, and logistics management.

- **SCM Requires a Systems Approach.** The scope of SCM encompasses an entire system, distinguishing it from strategies that look only at specific, internal functions of a company. As a result of a focus on the total process of a business, rather than specific functions within the business, value-adding or cost-reducing activities often transcend the organizational structure of the business. This means SCM is driven more by the need to make a chain and all of the businesses in that chain more competitive than only to optimize the internal functions of a single company within the chain. It is this act of crossing internal and external organizational boundaries that is a significant feature of SCM.

When managers recognize that business interests extend beyond the employee parking lot, management becomes much more challenging. Once a manager expands his management view from a single company focus to include other firms in the chain, the importance of looking at SCM as a system rather than a function is more apparent. "The task of the supply chain manager is to integrate the entire set of operations processes into a single supra-organization across organizational and in some cases across national boundaries." (Schary& Skjott-Larsen)

- **SCM Requires a Specific Business Philosophy.** Because SCM crosses the boundaries of many disciplines, taking what is needed from each firm to meet a specific problem that affects the entire chain, it becomes more of a way of thinking than a set of exact rules. As a result, management must be flexible, take into consideration the competencies of the other businesses in the chain, and seek solutions that depend heavily on the willingness to work together. In combination, these factors make up a business philosophy designed to improve the competitiveness of a chain rather than an exact set of steps to be followed.

- **SCM Requires a Focus on Strategic Decisions.** SCM can result in significant improvements and cost savings in a supply chain. However its fundamental goal is to improve the competitive position of all firms in the supply chain so that the collection of firms remains profitable. Although the competitive ability of a chain may be improved by eliminating inefficiencies and disadvantages, today it is necessary that firms build competitive advantages rather than focus solely on cost reductions.

"SCM has seen companies reformulating their strategies to take into account the competitive advantages that can be gained from improvements to the supply chain." (Burgess)

Logistics Roots

Because SCM has, at its roots, logistics and transportation, a better understanding of these functions can improve the competitiveness of both a firm and a supply chain.

The word “logistics” is French in origin (loger), a military term meaning the art of transporting, supplying, and quartering troops. Today, logistics is defined as the art of managing the flow of materials and products from source to user. The logistics system includes the total flow of materials, from the acquisition of raw materials to delivery of finished products to the ultimate users, and the related flow of information to control and record material movement. These activities are often referred to as distribution, physical distribution, materials management, and production planning and control. Elements of a logistics system include: product inventories, raw material acquisition, transportation and local delivery, and warehousing.

In any logistics system, many operational decisions must be made. These decisions include the number and location of plants, input suppliers, and warehouses; the mode of transportation; and communication choices.

Significance of Logistics

Economic Significance

The effectiveness with which materials are made available to the user–in the right place, at the right time, and in the right quantity–has a profound influence on the cost effectiveness of an enterprise. It has been estimated that the cost of physical supply and distribution exceeds $400 billion annually in the United States. Logistic costs are estimated to be 20 percent of the final product cost, and in some cases, may exceed 50 percent.

Management Significance

a) To concentrate on improving the efficiency of individual procurement, production, or selling operations is a dead-end road if the efficiency of an individual function throws the total system out of balance.

b) The logistics system has become an important competitive tool and is a key component in competition for control of distribution networks.

c) Many technological developments over the past 20 years have forced consideration of the logistics system as a whole. They are system-oriented developments (computers, software, communications, modeling, databases, containerization, and automated warehouses).

d) Logistics has become an important strategic consideration and not just a part of the business where costs are minimized. Companies have sought to distinguish themselves from competitors by providing superior customer service. On the other hand, financial concerns have led manufacturers and distributors to increase attention on managing logistic systems investment and costs.

Blending SCM and Logistics

Having identified the roots of logistics in SCM and the important role logistics has in SCM, it is important to define the relationship between SCM and logistics management. The Council of Logistics Management gives the following definition:

> *"Logistics is the process of planning, implementing, and controlling the effective flow and storage of raw materials, in-process inventory, finished goods, services and related*

> *information from point of consumption (including inbound, outbound, internal, and external movements) for the purpose of conforming to customer requirements,"* Council of Logistics Management (1982).

From the above definition, *logistics is focused on operational issues*.

SCM deals with the skills and resources of the entire supply chain–an extended enterprise with the aim of finding innovative strategies that enable each firm in the system and the system as a whole to achieve a competitive advantage. Those strategic solutions may be found through integration of all available system resources and are highly dependent on efficient integrated logistics solutions. The scope of SCM is wider than the scope of logistics.

Summary

The changing structure of U.S. agricultural exports requires changes in the competitive thinking of U.S. agricultural firms. With the shift in trade from bulk commodities to value-added products, a low price is no longer a sufficient competitive strategy. Both domestic and overseas buyers demand speed in delivery, product quality, consistency, and a constant stream of new products. The traditional competitive strategy of low cost is no longer adequate for businesses to succeed. Businesses in the agricultural sector require new thinking, new strategies, and new techniques to meet sophisticated customer requirements. This chapter described changes taking place in agricultural trade and discussed the importance of SCM as a competitive strategy for the agricultural sector.

Chapter Two: The Supply Chain for Agricultural Exports

A significant factor that has plagued the application of supply chain thinking to the agri-food sector is the unique characteristics of agriculture and agribusiness. This chapter provides a discussion of the unique aspects of agri-food supply chains and discusses why SCM optimization strategies for those chains require unique approaches and tools.

Uniqueness of Supply Chain in the Agri-Food System

Most analysis of SCM has been applied to industrial (i.e., nonagricultural) situations and based on experiences in the aerospace, electronic, and clothing industries. The analysis has assumed a production process completely different from that of agri-food products. There are five factors that differentiate the supply chain for agriculture from the industrial supply chain.

These factors are:

1. Consumers

Consumer demand for food continues to emphasize health, variety, and convenience. However, the greatest influence on the consumer's choice of food products appears to be nationality or race (Schaffner). In addition, food consumption is driven by unique consumer needs, such as nutrition, safety, sensory, and social needs that are all affected by a consumer's culture and the social environment.

2. Agri-Food Product Distribution

Just as consumers are different in different countries, product characteristics such as packaging, labeling, and distribution systems also differ among countries. While changes in rules and regulations must be faced by any exporter, the agri-food export supply chain must, not only take those changes into account, but also always accommodate the wishes of consumers. In some countries, consumers purchase food products daily from small shops. Packaging and product size are, therefore, important factors in the international food distribution system.

3. Role of Marketing in Supply Chain Solutions

An integrated planning system for the agri-food system has two drivers: availability of production and consumer demand. The importance of marketing strategies to reflect national consumer tastes, differing government regulations, and differing distribution systems so that a business may remain competitive becomes increasingly significant in an agri-food supply chain. The agri-food supply chain must provide optimal solutions for the "3 Rs" (right product, right place, and right time) to meet the marketing requirements of each country. In turn, optimal marketing solutions may be achieved only when issues associated with the supply chain, which is the guarantor of product delivery to the customer, are considered, such as product and input availability. Therefore, for the agri-food chain, there exists a requirement for a "natural" integration between product development, and marketing and customer service.

4. Nature of Agricultural Products

The perishable nature of many agricultural products increases the importance of storage, handling, and transportation. For example, a central challenge for the fresh produce industry is the availability of rapid, refrigerated transportation. For grains and potatoes, a significant issue is optimal, long-term storage. Fluid milk is processed into a number of products, each with different storage and transportation requirements. With the globalization of trade and the development of new storage and handling technologies, the agri-food supply chain has been transformed from reacting to seasonal production factors into a stabilizing mechanism to assure a stable supply of a product throughout year.

5. Continuous Material Flow Issue

It is well recognized that agri-food supply chains have uneven supply patterns, due to a variety of factors, such as weather or disease. An important focus of the traditional supply chain is the use of forecast to meet consumer demand. The supply chain assumed the continuous availability of inputs to meet demand forecasts. Uncertainty in the traditional supply chain arose from errors in forecasting demand, not from any variation in input availability. For the agri-food chain, the availability of raw agricultural production must be included in the forecast process. Because of the perishable nature of unprocessed agricultural products and the uncertainty of supply because of yield variability, the importance of forecasts of supply availability may easily exceed that of demand forecasts.

A Producer-Consumer Driven System

Due to seasonal production variability of unprocessed agricultural products, the agri-food system must adjust product availability to meet consumer demand patterns with inventories. This approach is required because of the uneven relationship between demand for food products and the supply of those products.

If most supply chain systems discussed in the literature are defined as “consumer-driven systems,” the agri-food supply chain may be defined as a “producer-consumer-driven system.” For consumer-driven systems, production plans are set, based on demand forecasts. With such a system, the production process may be adjusted to meet changing consumer needs over a specific timeframe. The implicit assumption is that supply, with enough planning and coordination with chain members, can be almost perfectly controlled. While demand and supply forecasts are equally important in the agri-food chain, the ability of chain members to control supply is limited.

Because of the factors specific to agri-food chains, it is impossible for agri-food chains to be purely consumer driven. Seasonal patterns of production and other factors such as weather and disease are beyond the ability of either a company or chain members to control. Consumers are often far away and have very specialized needs, to which agricultural production does not and cannot react quickly.

Agri-food supply chains may be defined as “production-adjusted, customer-driven systems” (see figure 9).

In figure 9, the left column represents the flow of material from the producer through to the customer. A horizontal line bisects the figure to indicate the movement of product across a country's borders. The right-hand column depicts the interchange between production and demand–the connection of actual, versus forecast, production and actual, versus forecast, consumer demand. The variation between actual and forecast production, when combined with demand uncertainty, underscores characteristics unique to agri-food supply chains. These characteristics are:

1. The timelag between actual production and product delivery to final consumer;
2. The importance of storage for seasonal production; and
3. The importance of the twin drivers of production and consumption to an integrated planning system.

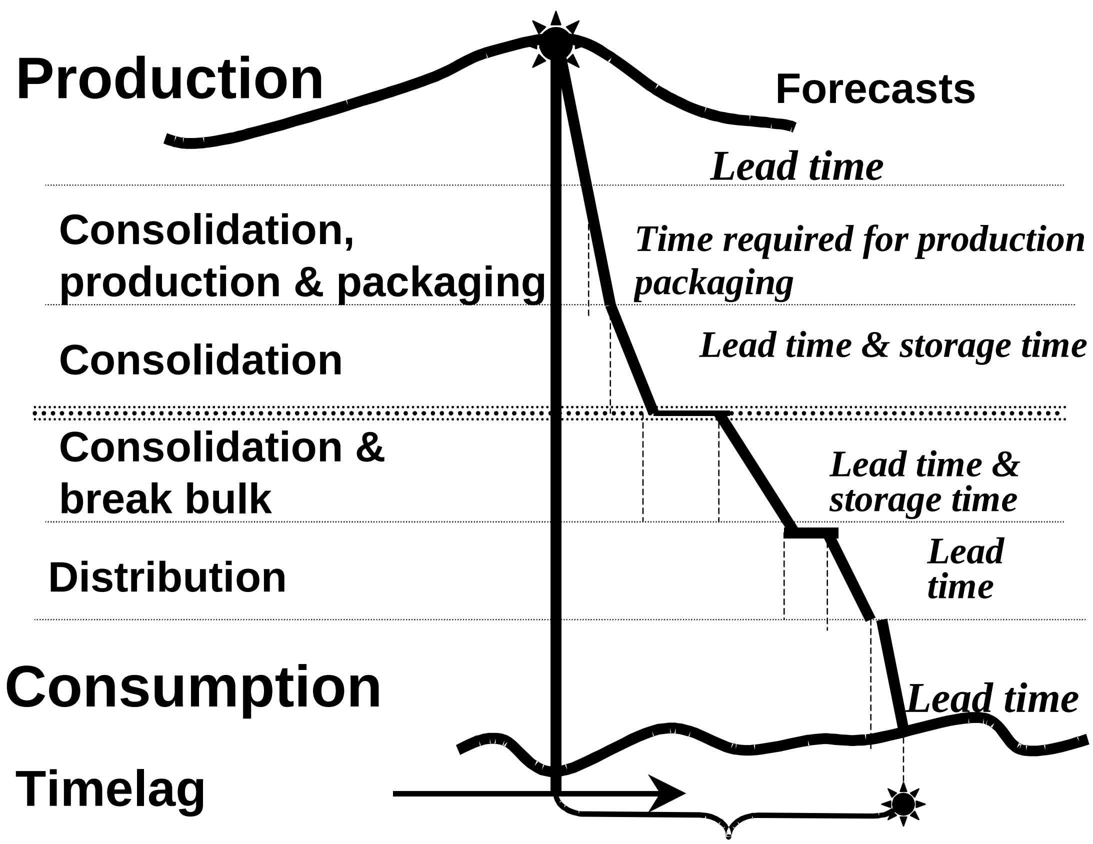


Figure 9. Food and agricultural supply and demand variation

Consequently, the conflict in the agri-food chain between production-driven reality and customer-driven reality is apparent. The challenge for SCM in the food and allied industries is to search for strategies to resolve this conflict. These strategies should consider the use of integrated planning to optimize the 4 Ps of the traditional marketing mix: product, price, place, and promotion.

For many nonbulk agricultural exports, the production side of the chain is dominated by the perishability of its outputs. Perishability places specific requirements on all of the 4 Ps. Further, agri-food chains for different products have their own storage, handling, packaging, etc. requirements. The characteristics unique to each of these chains underscore the inherent variability in commodity production and in the chains associated with that production.

Traditional definitions of SCM and logistics make clear that logistics deals with strategies but only for one of the Ps of the marketing mix–place. There are many tools to assist in the optimization of logistics just as there are many tools designed to optimize the supply chain. However, there are no "off-the-shelf' solutions to integrate all 4 Ps of the marketing mix to develop optimum SCM strategies for agri-food chains. This means to achieve competitive advantage through the use of SCM strategies, firms should realize that they must seek their own solutions to the problems that are unique both to them and to their industry. This means that any results from benchmarking processes should be adapted to the unique characteristics of the agri-food sector.

A useful tool to gain a better understanding of SCM is through set theory. Set theory is used to underscore the importance of knowing what is important both to customers and others in the supply chain, rather than focusing on what is important only internally.

There are three of sets of interest: Complement, Union, and, most important, Intersection (figure 10). Examples from the National Football League (NFL) are used to explain these sets.

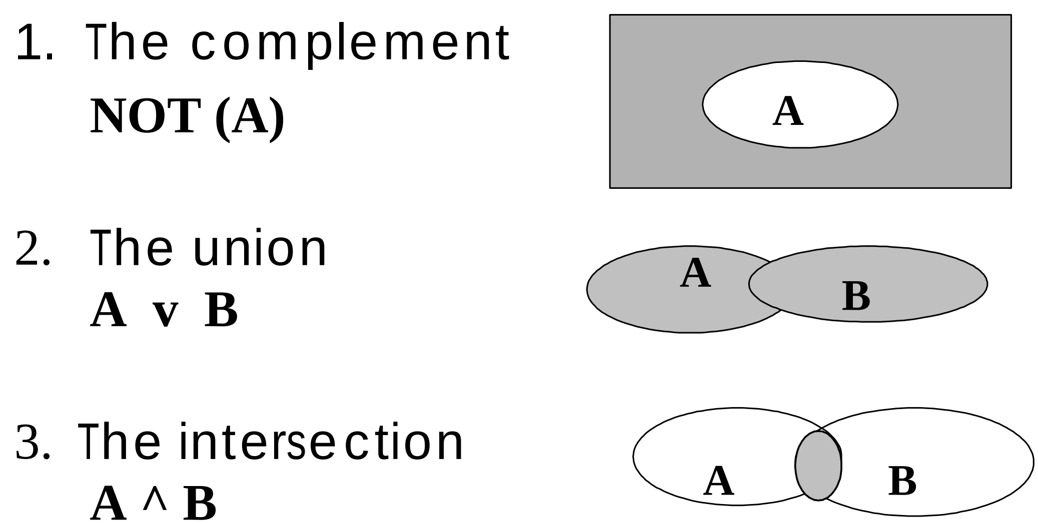


Figure 10. Theory of sets operations on sets

<u>Complement:</u> These are decisions that are unique. Each of these decisions is unique to each team. Decisions made for one team do not affect other teams. The sets are complements in that the decision made by each team is completely independent of the decision made by other teams.

Union: The NFL promotes the NFL and, by doing so, promotes all teams in the NFL, not just one. So, the promotional interests of the NFL cannot be separated from the promotional interests of the individual teams. Because promotion of the NFL helps all teams, there is a union of interests for all in the system for good promotion.

Intersection: Each week, there are games in which the interests of one team overlap with the interest of at least one other team–its opponent. Both teams–and no others in the NFL–are affected by certain events. Both teams want good refereeing, good weather, no injuries, and well-behaved fans. Because both teams are affected by these events, they have an intersection of interests. They have shared interests.

The key area of interest for SCM in this overview of set theory is the importance of identifying where risks overlap. Questions firms should ask when that overlap is identified include: where are the mutual concerns, and where is the intersection of our risks and interests? A firm's ability to answer such questions moves it a long way down the path toward a well run supply chain and a supply chain that responds well to all situations, including the uncertainty of agricultural production. A firm that wishes to optimize its supply chain, particularly in the agri-food sector, must identify those issues for which it has shared interests; that is, those issues for which there is an intersection of sets.

Supply chains for successful agri-food exporters integrate business processes that are designed to react to changing customer demand and to variations in producer supply. The production side of these chains is characterized by three factors:

1. Production is primarily commodity based;
2. Production is highly seasonal; and,
3. Products are perishable.

Taking into account the above factors, agri-food supply chains are, in the short-run, driven more by the production end of these chains than by the consumer end. From the consumer end, another factor further complicates the agri-food supply chain: export markets for food products are extremely diverse, with differing distribution systems, political situations, packaging and labeling requirements, and government regulations. The recent problems with genetically modified corn in both Japan and the United States or the outbreak of various diseases in the red meat sector in Europe underscore the variability in demand that is difficult to forecast.

Summary

Just as there are characteristics of SCM that make it distinct from other competitive strategies, such as cost leadership or generic promotion, the supply chain for agricultural products traded internationally also has factors that differentiate it from the industrial supply chain. Five of these factors were discussed:

- Unique customer preferences for food;
- Differing food distribution requirements, such as labeling or packaging requirements;
- Integration of production and marketing;

- Product perishability; and
- Product seasonality.

As a result of these factors, the supply chain for agricultural exports is both production and consumer driven. Consequently, the successful use of SCM in agriculture requires chain members to recognize and identify areas of shared risks so that those risks–either from a production or from a consumer perspective–are minimized.

Chapter Three: The Potential for SCM To Increase the Competitiveness of American Agriculture

The movement of American agricultural exports toward a larger and larger share of nonbulk food products in total food and agricultural trade (national and international), as discussed in chapter one, will continue and, it is expected, will increase. This trend is expected to accelerate because the potential for faster, more coordinated systems of product movement, processing, and delivery will continue to lower costs while maintaining product quality, freshness, and safety. This is what a rapidly urbanizing, income increasing, and more demanding world population is currently demanding.

The trend is not without problems, however. There is a downside to this inevitable trend; because of the events on September 11, awareness has been heightened, for example, about the transmission of foodborne and animal and plant diseases. Bovine Spongiform Encephalopathy (BSE or Mad Cow Disease) in Japan affected consumer perceptions about the safety of beef. The United States banned imports of Spanish clementines because of infestations of Mediterranean fruit fly larvae, and Japan and other countries have periodically restricted imports of U.S. poultry because of animal disease concerns. These and other sanitary/phytosanitary issues will be an important and continuing theme that affects trade in nonbulk commodities, particularly perishable products.

Who will be the major food-trade participants in the future? There has been a great concentration of U.S. exports to a few middle- and high-income markets in three regions;

however, U.S. imports are from a more diversified set of countries. The ability of U.S. exporters to meet the needs of these new markets will depend on the capacity of countries/companies or other entities to take advantage of unique opportunities: exploiting off season production, for example, in the southern hemisphere, or becoming more competitive by being more adept at marketing and in lowering costs along the supply chain.

In terms of the outlook for trade in food and agricultural products, the United States is in a very strong competitive position, with a world-class transportation and communication system and a strong comparative advantage in agriculture–livestock production and many other products. Despite its strong position, the U.S. agricultural sector is facing growing competition. Imports have been rising and represent a larger share of the market than before. And export competition is becoming more intense; there are simply more competitors. Brazil and Argentina, for example, are investing heavily in infrastructure–railroads, highways, bridges, and ports–recognizing that an efficient transportation system is critical to their success in a global economy. It is estimated that South America surpassed U.S. soybean exports in 2001–27.7 million tons, versus 26.7 million tons.

Thus, the business of being competitive in the future will not just be about keeping on-farm costs down; it will be about keeping all costs along the supply chain down. It will also be about minimizing regulatory costs and addressing all of the uncertainties inherent in the food chain. This chapter discusses two methods currently used to improve supply chains: containerization of exports and the Supply Chain Operations Reference model.

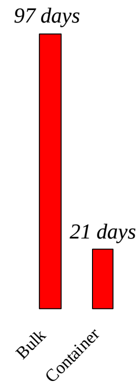
Containerized, Versus Bulk, Systems

The U.S. transportation system for the export of agricultural products was developed to move bulk commodities. Large vessels, high-capacity loading and unloading systems, and high-volume inland transportation and storage facilities are all required for efficient bulk transportation.

As indicated in chapter one, the market for bulk exports has declined and has been replaced with growing markets for value-added products. With the increased importance of value-added products comes the need to maintain product characteristics–quality, for example–while moving smaller individual volumes of products. The use of containers to move agricultural products has increased substantially over time. With containers, the ability to control all aspects of product movement through the supply chain improves considerably. Consequently, the increased use of containers provides an excellent opportunity to improve supply chain performance for a variety of products. Figure 11 details the reduced shipping time needed to export Canadian wheat when containers are used. While reductions in shipping time may reduce costs, containerized shipments may also improve customer service by providing faster response to customer requests, targeting shipments more carefully, and reducing handling and storage en-route.

Causal factor: Reducing transaction costs

Bulk handling system		*Container system*	
Farm storage		*Farm storage*	
Local delivery	*1*	*Local delivery*	*1*
Primary elevator	*40*	*Intermodal terminal*	*2*
Rail hopper cars	*11*	*Double-stack train*	*2*
Export terminal	*19*	*Intermodal port*	*2*
Bulk shipment	*15*	*Container ship*	*11*
Import terminal	*10*	*Intermodal port*	*2*
Local delivery	*1*	*Local delivery*	*1*
Total days	*97*	*Total days*	*21*



Source: Barry Prentice, *Re-engineering Grain Logistics: Bulk Handling Versus Containerization*, Proceedings of the 40th Annual Meeting of the Transportation Research Forum, October 1998.

Example refers to shipping Canadian wheat to overseas destinations

Figure 11. Shipping time much shorter for containerized, versus bulk, systems

Supply Chain Operations Reference Model (SCOR). A well accepted methodology to improve the performance of a supply chain is the Supply Chain Operations Reference model (SCOR). The SCOR model was developed and endorsed by the Supply Chain Council (http://www.supply-chain.org). It is widely used in the automotive, aerospace, and computer industries. Although its use in agriculture is limited, SCOR may be modified to accommodate the factors that make vertical supply chains in the food industry unique.

SCOR helps to define and describe a system and, most importantly, establishes a measurement process. However, once the process is captured, the model assumes that the process can be controlled and managed. For many firms in the food supply chain, inputs cannot be completely controlled or managed. If inputs cannot be completely controlled or managed, it means the system is forced to respond to supply-driven events, not just to demand-driven situations.

Nevertheless, describing and measuring a system is a valuable undertaking, even if significant parts of the chain cannot be controlled or managed.

The basic tenets of the SCOR process are Plan, Source, Make, and Deliver. Each of these components is defined below and discussed in terms of its role in the food and agricultural chain.

Plan: **Processes that balance aggregate demand and supply to develop a course of action which best meets the established business rules.**

In this core management step, a business assesses supply resources; prioritizes demand requirements; and plans inventory and distribution requirements, production runs, and material required for the runs. All of these are also important considerations for any raw ingredient-based food company. However, for selected companies that produce raw ingredients and sell processed consumer products, such as dairy cooperatives, problems exist. Inventory planning assumes control of at least one end of the chain–either demand or supply. Inventory planning for agricultural businesses is extremely difficult. If a business can know exactly the quantity and quality of the harvest, the business can then plan the inventory that balances aggregate supply and demand. If not, the company quickly loses its ability to manage the chain optimally. The best it can achieve is suboptimal performance.

Source: **Processes that procure goods and services to meet planned or actual demand.**

Management of the sourcing infrastructure, such as vendor certification, sourcing, quality, or vendor contracts, is clearly a desirable goal. The chain must recognize that uncontrollable events will affect product procurement. As a consequence, input standards may need to vary daily, weekly, or annually. Input variation depends on environmental and biological factors–too much rain, not enough rain, disease–not a supplier certification program. A vendor may have a contract to deliver inputs, have clearly identified standards for those inputs, and be a certified supplier. However, factors completely outside the vendor's control could result in products delivered that do not match established parameters. As a result, input standards should be indicative rather than absolute. Such an approach is important for SCM in that one part of the chain tells the other, "Here is the problem. It is beyond anyone's control. It affects us both so we need to work together to solve it."

Make: **Processes that transform goods to a finished state to meet planned or actual demand.**

A product must sometimes be produced based, not on customer requests, but on what is available. A vertically integrated company may face a very large supply of inputs because the weather was excellent or a small harvest because of disease. Examples include beer processors sourcing different types of malting barley, the unexpected presence of genetically modified corn in inventory, or foot-and-mouth disease problems. Consequently, the processes may all be perfect for production but input availability could force modification in the process.

Deliver: **Processes that provide finished goods and services to meet planned or actual demand, typically including order management, transportation management, and distribution management.**

For vertical businesses in the food industry, several subcomponents of this core management process are affected by environmental and biological factors unique to the industry:

Order Management. Input prices could be affected by unexpected variation in quality/availability with resulting impacts on the cost of production. Consequently, there must be close and continuous communication to assure that quotations reflect changing input supply characteristics.

Warehouse Management. Differing labeling and health requirements for export destinations affect packaging and product configuration such as size. There should be a common denominator established for products before labeling and packaging are performed. That common denominator could be a product characteristic (frozen, chilled, or dry), degree of processing (minimal or extensive, including aging), or countries with similar labeling requirements (does not contain genetically modified ingredients) or processing requirements (halaal or not). Order consolidation could also be a function of the geographic location of customers (Southeast Asia or Northern Europe) or market risk (low-risk markets such as quota markets or high risk in new or developing markets).

Transportation and Installation Management. Characteristics of final markets differ. Special handling and inspection requirements are often needed, both for export from a country and import into an overseas market. Certain phytosanitary inspections could be required before a product is exported just as other inspections will most likely be required before a product is cleared for import. These inspections, while to a degree controllable, bring additional uncertainty into the chain.

Manage Delivery Infrastructure. The ability to manage channel business rules may be limited. These rules can quickly change as a result of unanticipated issues such as new labeling requirements or disease problems either at home or in the export market. Delivery quality is no more important for food products than for other products, but government inspectors are frequently required. Because the inspectors are looking for a variety of things, quality can become more subjective despite the best attempts to make it objective.

Summary

SCM, containerization, and SCOR all may be used to improve the competitiveness of agricultural exporters. Although competition for U.S. agriculture is presently coming from a limited number of countries, it is unknown where the competition will come from in the future. Consequently, it is important for U.S. agricultural exporters to be flexible in order to meet the challenge of constantly changing competition and consumer requirements. Combining this needed flexibility with the shift from large volumes of bulk commodities to smaller shipments of value-added products could easily mean that there is a need to limit the amount of investments in fixed facilities. As a result, SCM is an important tool to assure rapid response to changing market conditions while limiting capital investment.

Chapter Four: Case Studies of SCM in Selected Agribusiness Companies

Four firms involved in various aspects of agriculture, including exports, were interviewed for this research. The firms ranged in size from multibillion-dollar sales with a strong export orientation to a small regional farmer cooperative. None of the firms handled horticultural products, although several were involved with perishable commodities.

All of the firms were familiar with SCM, although each had a different definition for it. Three of the firms displayed common traits:

1. SCM is viewed as simply another name for logistics;
2. Senior executives did not look at SCM as a competitive tool;
3. There was extremely limited contact between logistics officials and marketing officials within the company;
4. Contact with customers or suppliers was important but viewed in a rather adversarial light; and
5. The companies placed considerable pressure on logistics officials to reduce cost of movement and storage rather than reducing total system costs.

Only one company looked at SCM as a competitive tool. The person in charge of SCM with this company had both visibility and support from senior levels.

Firm One

Firm One is a global agribusiness firm with sales in excess of $5 billion. It has strong consumer brands domestically and is a significant exporter of bulk and perishable products.

For several product lines, the company is vertically integrated from farm level to retail outlet. Because of this vertical integration, SCM is most easily applied to them. The firm takes delivery of product at the farm gate and uses optimization and routing methodologies to assure efficient farm-to-factory movement of the raw product. Demand forecasting appears to be used extensively to increase the efficient use of warehouses and to assure appropriate levels of inventory are maintained.

The use of analytical techniques to improve system performance is an important characteristic of SCM. Because these techniques require information that is proprietary, use of such techniques is often restricted to internal analysis. However, with the vertical integration of the company, the use of these techniques is easier because of the transparency of commodity operations and because many of the supply chain tasks are performed internally.

Although the company does have a director of SCM, that position is in the food retailing area. This positioning implies that SCM may be viewed as a competitive strategy that focuses on retail sales, such as efficient consumer response, rather than a total intracompany and intercompany competitive strategy. While the food retailing division of the company may use SCM as a competitive strategy, SCM is most effective when used as a corporate strategy rather than a divisional strategy. For example, products from different divisions may require similar packaging (intrafirm and interfirm discussions), or a broad range of products may require transportation to common destinations (intrafirm discussions).

It is difficult to comprehensively apply SCM to this firm because it is a cooperative. Consumer demand is met using product that flows into the chain from farmer members. The flow of product into the chain continues, in the short to medium term, regardless of consumer demand. The chain then becomes driven by both consumer demand and member supply.

With a supply chain driven both by consumer demand and producer supply, the export market often becomes a residual market. This means export markets may be viewed by this firm as a product disposal market rather than a commercial market. For example, if demand for consumer goods drops, while farmer-supplied product continues to enter the chain, there may be an aggressive attempt to move the excess product into lower value export markets. On the other hand, if demand for consumer goods increases appreciably, there is a high probability that export volumes will be reduced to meet the increased domestic demand for consumer goods.

Overall, it appears that the company is probably doing a good job to minimize internally generated transportation costs. As with any supply chain, however, it is the total delivered cost that is important from a competitive perspective. It does not appear that this firm is using SCM in its export operations as a competitive tool.

Firm Two

The second firm interviewed was a regional firm that provides a broad range of input products and services in addition to grain merchandising expertise. Additional services to farmers include comprehensive advice on implementing grain and livestock production systems. Total revenue exceeded $1.5 billion in 2001.

From the supply chain perspective, the firm has an important role in improving the competitiveness of agricultural exports. In fact, inclusion of firms involved in the input sector of the supply chain is key to a competitive chain. Although the firm is not actively involved in exporting agricultural products, it is a key participant in a chain that produces products–both value-added and bulk–for eventual sale overseas. Consequently, if the firm improves its efficiency and operation, those improvements may be passed on, both up and down the chain, in the supply chain for grain and livestock. As a result, the competitiveness of the entire chain is affected, for better or for worse, by the performance of this firm.

Firm Two is familiar with the SCOR model discussed previously. The firm has made an effort to determine if, and how, a supply chain methodology such as SCOR could be used. However, neither the SCOR model nor other SCM methodologies have been adopted.

Despite its interest in the SCOR model, the firm is pursuing a policy similar to that of most firms in the agri-food chain. The firm looks at logistics and transportation as internal cost centers.

This means the focus of logistics and transportation is to achieve the lowest cost for services provided. The emphasis is on reducing traffic rates, often by guarantying a specific volume of product to be moved. A relationship between the buyer and seller that focuses only on price will tend to place that relationship on an adversarial rather than a mutually supportive basis. It should be recognized that both the buyer and seller have some risks in common. Sharing those risks, in some way, will help both parties and make those parties more competitive. (Bailey and Norina 2000)

The firm indicated that, while the importance of SCM is recognized, at this point, it is only used in specific internal areas of the company such as warehouse management. The firm uses optimization techniques to improve the efficiency of its operations, but those techniques are not applied throughout the company.

An example of one area for which the firms could apply SCM is in the relationship between the firm's buyers and suppliers. As would be expected, buyers develop, as they should, good working relationships with suppliers. Because of these relationships, individual farm input supplies may be procured in a reasonably efficient way. However, the intrafirm communication that is necessary for efficient supply chain operation appears to be quite limited. Without good intrafirm communication, several people from this firm could be negotiating with one supplier for products. An alternative perspective is for the firm, as a supply chain member, to negotiate with supplier firms as supply chain members, rather than the person-to-person negotiations that are currently taking place.

The firm has taken steps to increase interfirm communication. It has begun looking to vendors to manage inventories of several product lines. Although vendor management of inventories is not a new business direction, it does bring the buyer and supplier closer together. The risks of the two are more explicit, and, as a result, efforts may be made to reduce shared risks. The attention of the firm has begun to shift from intrafirm strategies to include interfirm strategies.

Firm Three

Firm Three is one of the largest farmer-owned co-ops in the United States. Its revenues exceed $1.7 billion. It operates primarily east of the Mississippi. It purchases, processes, or manufactures feed, seed, fertilizer, and fuel. In addition, it sells farm and animal health supplies through 1,100 local dealers. It also markets grain and fish products produced in its territory.

As with Firm Two, although not an exporter, the role of Firm Three in the supply chain for agricultural exports is significant. While Firm Two has recognized the potential importance of supply chain improvements through SCOR, Firm Three continues to focus on low cost as its main strategy. The firm states, in its annual report, that it is seeking to exercise its bargaining strength through taking advantage of its size. While such an approach on cost reduction through economy of scale is a recognized competitive method, the emphasis on cost is difficult to extend into a sustainable competitive advantage for the firm and its customers. Certainly, cost reduction at various points in a supply chain is important, but unless the total cost of a product is reduced, the strategy is not a sustainable long-term competitive strategy.

The challenge of implementing an SCM competitive strategy in this firm is underscored by the short planning horizon used for a significant part of its logistics operations. The time horizon used appears to vary between a day and a week. Because of the unique challenges faced by firms operating in the agribusiness industry–seasonality and perishability for example–a planning horizon of 1 week will result in the firm's responding to short-term variability rather than attempting to make its chain efficient throughout the year. With more than 1,000 stores, it is believed that there are opportunities for significant improvements in areas that will reduce costs, such as inventory management, in addition to volume buying.

It is believed that the view of SCM taken by this firm–"the logistical control of product from origin to end use"–is common with American agribusiness. Further, the short planning horizon, the apparent lack of supply chain optimizing tools, and the emphasis on reducing input costs rather than total system cost, are assumed to be frequently encountered throughout American agriculture.

Firm Four

Firm Four is one of the world's largest agribusinesses. It is a very significant exporter of agricultural products–both in bulk and value added–and is also a major participant in the domestic food industry. Consequently, it is not surprising that the firm was both innovative and aggressive in its use of SCM. Although the role of SCM in the firm does not appear to be a corporate competitive strategy, it, nevertheless, is highly visible in the corporate structure.

The firm has created a supply chain group in its corporate staff. These specialists may be hired by any division in the firm as in-house consultants. This SCM group is a profit center rather than a staff function. Such an approach is not unique but does permit supply chain concepts to become part of the company's competitive strategy, beginning with separate business divisions. In this way, the company is able to introduce best practices and business creation with the divisions but only if the divisions ask for the assistance.

Although the supply chain effort is reasonably recent for this firm, the supply chain services are in constant demand. Primarily external customers drive the demand for their services. It is believed that internal managers are too focused on intracompany issues, as with Firm Three, to look at possible chain improvements outside of the company. As external customers increase their need and desire for chain improvements, such as organic feedstuffs, the firm's brand managers are turning to the new corporate SCM area for guidance.

For example, if an external customer is exporting organic poultry, it would need to have assurances that the feedstuff delivered by Firm Four is organic. In turn, the firm would need to have a system in place to assure that the feedstuff purchased is organic. With a product such as organic feed, one of the primary interests of all chain participants is the integrity of the chain to deliver to customers what is required and guaranteed. The relationships of chain participants go beyond that of seeking the lowest cost into areas of mutually shared risk.

Firm Four has attempted to measure the value it creates with improvements in the supply chain through developing supply chain metrics. Such an approach, while difficult, will eventually create enough demonstrable improvements so that internal divisions will recognize that it is in their self-interest to adopt SCM.

The firm does not have, as an operational goal, implementation of SCM throughout the company. It does, however, have improved supply chain performance as a part of the company philosophy. It is the decision of each division whether or not to implement SCM. However, as external customers demand the adoption of SCM and as the firm develops financial metrics that demonstrate the advantages of SCM, it is believed the firm will increasingly look to SCM as a significant corporate competitive strategy.

Summary

Four firms involved in various aspects of agriculture, including exports, were interviewed for this research. The firms ranged in size from multibillion-dollar sales with a strong export orientation to a small regional farmers cooperative. None of the firms handled horticultural products although several were involved with perishable commodities.

All of the firms interviewed in this study were fully aware of SCM. Although their definitions of SCM varied, the increasing importance of SCM was recognized at the staff level. However, only Firm Four viewed SCM as a competitive strategy. The other three firms tended to look at improvements in the supply chain primarily as an attempt to reduce costs within the company with little recognition of the importance of working with other companies in the supply chain.

The transition from an internal, intrafirm focus to a more inclusive, interfirm focus is difficult. It will be even more so with firms involved in agricultural exports. As indicated by the firms interviewed, the primary focus of SCM is seen as a tool to reduce costs, primarily transportation and logistics costs. Because in the past, the preponderance of agricultural exports were bulk commodities for which price is the most frequent competitive strategy, it is understandable that most agricultural firms, including those interviewed, look at cost reduction as the most appropriate competitive strategy. However, increasingly, customers look to a variety of factors, in addition to price, in purchasing agricultural products. Consequently, product selection criteria could include delivery parameters or unique quality characteristics that the current marketing system does not recognize. With the long history of looking only to price as the competitive factor, the sector of American agriculture dealing with exports may find itself increasingly at a competitive disadvantage.

Companies such as Firm Four recognize the importance of SCM to both itself and its customers. In response to customer requests, the firm has worked with internal divisions to respond to customer needs. It is in response to external requests that SCM in agriculture seems to best respond.

Chapter Five: Techniques To Increase the Efficiency of the Agricultural Export Supply Chain

This chapter describes two reasonably simple and inexpensive techniques that may be easily used by supply chain members to improve supply chain performance.

The responses from the firms interviewed during this research about their use of SCM indicated that, except for one firm, SCM is not a widely used strategy. There could be a number of explanations for the lack of use of SCM. Firms often look to external sources when attempting to implement new ideas or strategies. For many firms, the costs of hiring external resources to review implementation of SCM or the potential costs associated with its implementation are a significant barrier to adoption.

Although SCM, as previously defined, may involve capital expenditures and some risk, there are methods to initiate supply chain analysis and supply chain methodologies, at the firm level, without capital expenditures and with minimal risk. More importantly, if a firm is able to unilaterally begin activities that extends its planning time horizon, then an important first step is taken along the road to adoption of SCM.

The purpose of this chapter is to provide examples of how a firm may initiate supply chain thinking and analysis with little capital investment. The first example examines the situation when two firms have both shared interests and private interests and how those interests may be balanced to optimize the supply chain in which they operate. The second example provides a technique to determine the port of export for products produced in different plants and exported to several countries.

Optimum Selection of Differing Company Goals

For SCM, a critical step for a firm is the recognition that its performance has an impact on the performance of other firms in the chain and, eventually, on the entire chain. Consequently, the relationship a firm establishes with others in the chain is extremely significant. This example provides a method by which two firms may objectively achieve an optimum agreement when the two firms have differing internal and external goals.

For this example, SCM is defined as an integration of each chain member's organizational activities in order to achieve particular objectives through achieving systemwide objectives. Organizational activities were divided into two groups:

1. Primary activities (inbound logistics, operations, outbound logistics, marketing and sales, etc.) and
2. Supporting activities (infrastructure maintenance, human resource management, financial management, product development, procurement, etc.).

Each of the above listed activities may be performed either by the organization itself or outsourced–performed by another supply chain member(s). If the firm decides to outsource an activity, that action establishes supply chain relationships with another chain member(s) for which those outsourced activities are primary activities. In the researcher's view, the objective of SCM is to integrate outsourced activities of one supply chain member with the primary activities of other chain members. This area of outsourced activities may also be referred to as the intersection of sets of goals where that set is not empty. (Bailey)

The specific goals of each chain member may be achieved through establishing a set of supply chain-wide goals and attempting to meet those goals through cross-enterprise integration. Efficient use of such an approach requires an analytical tool that evaluates the alternatives available to supply chain members while taking into consideration each firm's specific (intrafirm) goals.

Each firm in a supply chain has specific objectives that may be achieved through supply chain integration. For example, objectives may be defined from the mission statement, financial goals, etc. The number of objectives and their definitions are different for each supply chain member. Some of those objectives are of interest only within the firm (private actions), while other objectives may best be met through coordination with firms outside the business (joint actions). Each firm has private actions that may be affected by joint actions and joint actions that may be affected by private actions. Because joint actions are, by definition, actions that affect two or more chain members, some methodology should be established so that the chain members may mutually rank those objectives while taking into consideration private actions.

The ability to mutually rank goals and objectives is a key component of SCM. Without agreement on the importance of goals that affect shared objectives, firms will reduce joint actions and increase private actions. Consequently, a methodology to evaluate and rank joint and private actions was developed (figure 12).

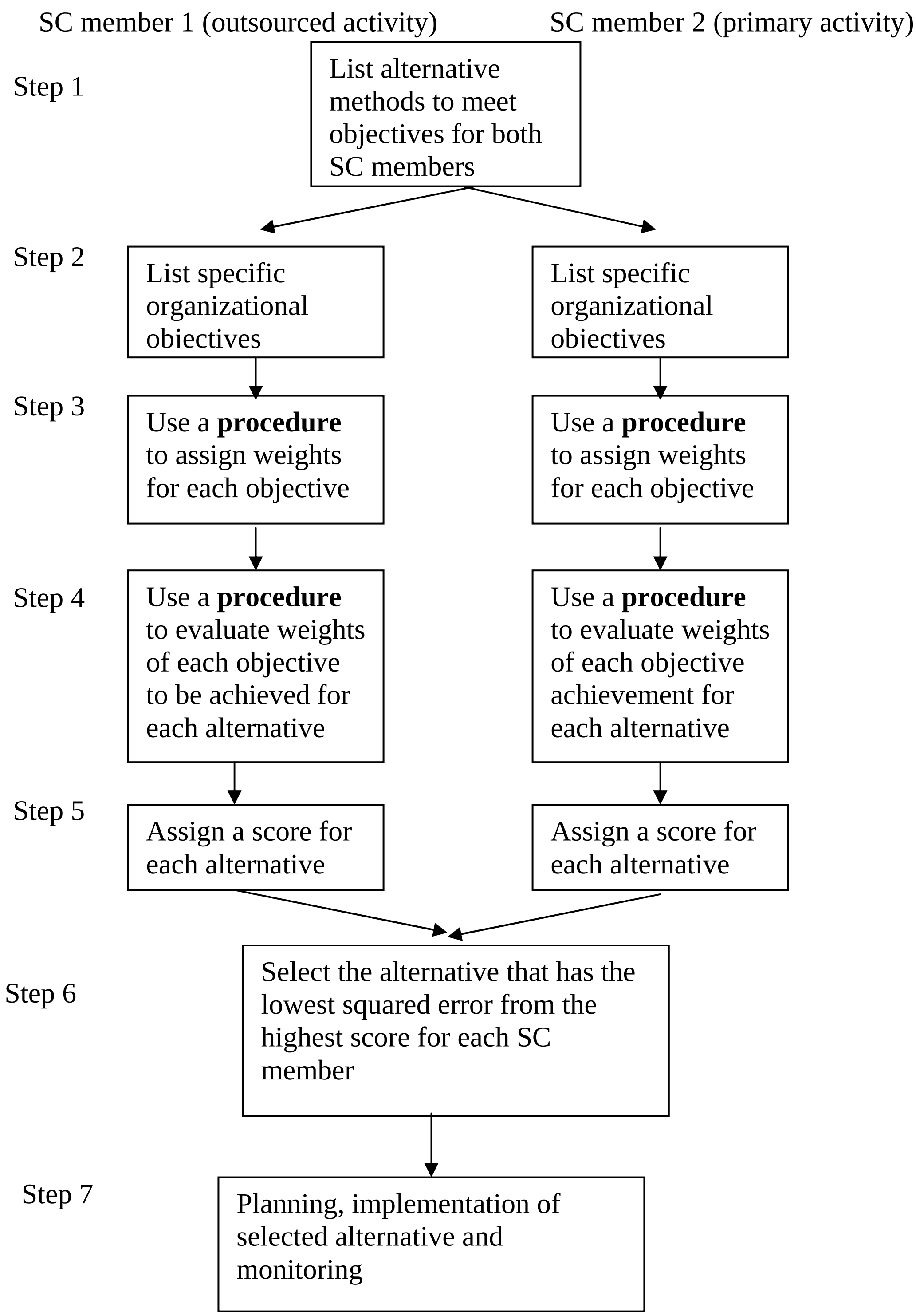


Figure 12. Sequential steps in evaluation of supply chain alternatives

Step 1. Supply chain members list and agree upon a set of integrated alternatives available to supply chain members to achieve system goals.

Step 2. Each supply chain member identifies its own specific objectives to be achieved as a result of supply chain integration. For example, organizational objectives (private actions) defined from the mission statement, financial goals, or other internal communications. The number and nature of those objectives vary across supply chain members.

Step 3. Utility theory is independently applied by each supply chain member in order to assign weights to each objective identified by individual firms in step 2.

3-A) All objectives are defined in step 2 for supply chain member k (k=1,2).

(Objective 1,…… Objective $_{nk}$) are pair wise compared. Results of these comparisons are placed in a pair wise comparison matrix ($C^k_{i\,j}$ k=1,2; i=1,…n_k ; j=1,…. n_k).

Table 1. Pair wise comparison matrix for SC-member k objectives

	Objective $_1$	. . .	Objective $_j$	. . .	Objective $_{nk}$
Objective 1	1	. . .	$C^k_{1\,nk}$	. . .	$C^k_{1\,nk}$
. . .	. . .	. . .	. . .	. . .	. . .
Objective $_I$	$C^k_{j\,1}$	. . .	$C^k_{i\,j}$	. . .	$C^k_{i\,nk}$
. . .	. . .	. . .	. . .	. . .	. . .

	Objective $_1$	. . .	Objective $_j$	. . .	Objective $_{nk}$
Objective $_{nk}$	$C^k_{nk\,1}$	. . .	$C^k_{nk\,j}$	. . .	1

For example, if the achievement of objective 1 is five times more important than the achievement of objective 2, then $C^k_{1\,2} = 5$ and $C^k_{2\,1} = 1/5$.

In this matrix:

$C^k_{ji} = 1/C^k_{ij}$

and

$C^k_{j\,i} = 1$ if i=j

3-B) The matrix is transformed to normalized form. Each element is divided by the sum of all elements in the corresponding column.

$$\overline{C}^k{}_{ij} = \frac{C^k{}_{ij}}{\sum_{i=1}^{n_k} C^k{}_{ij}} \qquad \text{(formula 1)}$$

3-C) For each row, an average value is calculated. This step gives weights to each objective.

$$W^k{}_i = \frac{\sum_{j=1}^{n_{k1}} \overline{C}^k{}_{i,j}}{n_k} \qquad \text{(formula 2)}$$

i= 1, …. n_k

3-D) The initial pair wise comparison matrix is multiplied by the “objective weights” column.

$$\overline{W}^{k}{}_{i} = \sum_{j=1}^{n_k} W^{k}{}_{j} \times C^{k} ij \qquad \text{(formula 3)}$$

i= 1, …. n_k

3-E) The resulting column is synthesized by dividing each element by the corresponding objective weight from 3-C.

$$WN^{k}{}_{i} = \frac{\overline{W}^{k}{}_{i}}{W^{k}{}_{i}} \qquad \text{(formula 4)}$$

i= 1, …. n_k

3-F) A "consistency index" is calculated as below:

$$consistency\_index_k = \frac{\sum_{i=1}^{n_k} WN^{k}{}_{i} - n_k}{n_k - 1} \qquad \text{(formula 5)}$$

If the consistency index determined is divided by the consistency index of a randomly generated pair wise comparison matrix (table 2) and results in a value less than 0.1, then the initial pair wise comparison matrix is sufficiently consistent.

Table 2. The consistency index of a randomly generated pair wise comparison matrix

n_k	3	4	5	6	7	8
RI	0.58	0.9	1.12	1.24	1.32	1.41

Random indexes (RI) in table 2 are calculated as the average values for consistency indexes if entries in the pair wise comparison matrix were selected randomly. If this consistency index divided by the consistency index of a randomly generated pair wise comparison matrix (table 2) is equal to or greater than 0.1, the decision maker has significant inconsistency in defining the initial pair wise comparison matrix. Values in this matrix must be reevaluated and made internally consistent.

This may be described by the following logical statements:

$$If\ \frac{consistency\_index_k}{random\_index\_for\_n_k} < 0.1 \quad \rightarrow \text{sufficient consistency}$$
$$If\ \frac{consistency\_index_k}{random\_index\_for\_n_k} \geq 0.1 \quad \rightarrow \text{significant inconsistency} \qquad \text{(formula 6)}$$

Step 4. The following sequential procedure may be used to evaluate the weights assigned for achieving each objective for each alternative under consideration (figure 13).

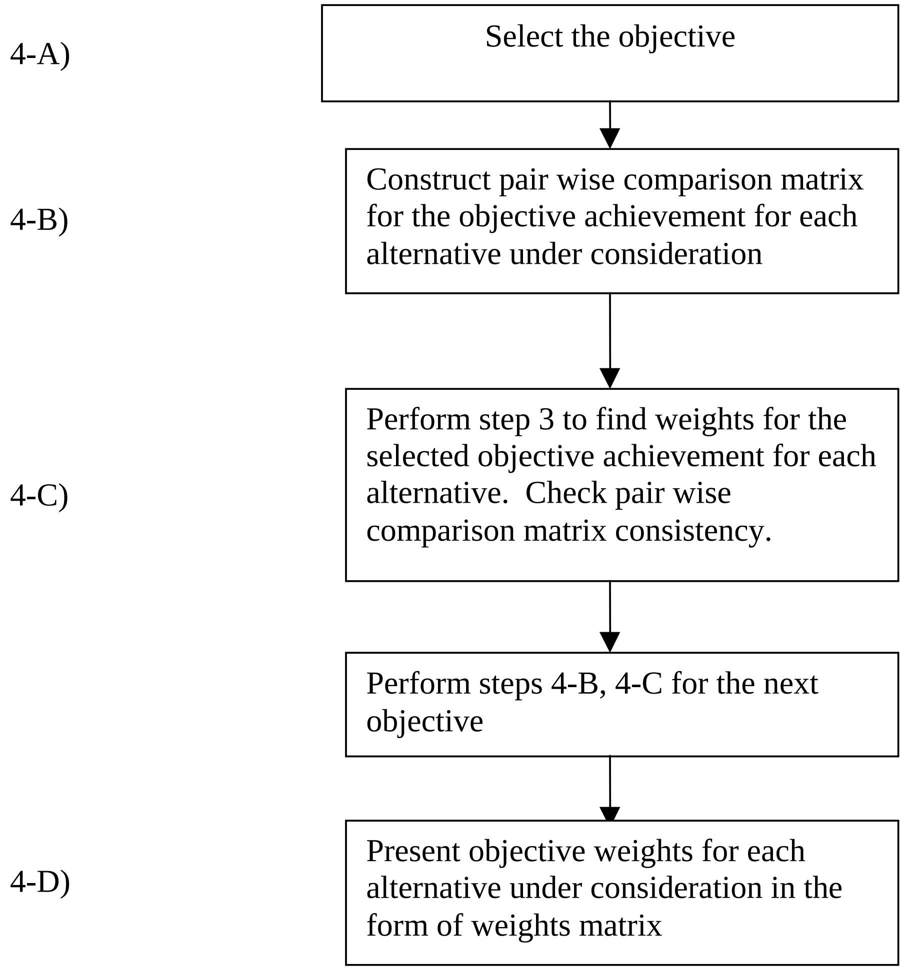


Figure 13. Sequential steps in the evaluation of weights of each

4-A) Both supply chain members linked through their supply chain relationship should rank the same array of alternatives ($n>1$).

4-B) Firm k ($k=1,2$) uses the above procedure to construct a pair wise comparison matrix of available alternatives based on the level of achievement of each of objectives:

For each objective $j=1....n_k$, construct a pair wise comparison matrix A^{kj} level of objective j achieved by firm k (table 3).

Table 3. Pair wise comparison matrix for the alternatives to achieve objective j by SC member k

	Alternative $_1$	. . .	Alternative $_m$	. . .	Alternative $_n$
Alternative 1	1	. . .	$A^{k\,j}{}_{1\,j}$	. . .	$A^{k\,j}{}_{1\,n}$
. . .	. . .	. . .	. . .	. . .	. . .
Alternative $_i$	$A^{k\,j}{}_{i\,1}$	. . .	$A^{k\,j}{}_{i\,m}$	. . .	$A^{k\,j}{}_{i\,n}$
. . .	. . .	. . .	. . .	. . .	. . .
Alternative $_n$	$A^{k\,l}{}_{n\,1}$	. . .	$A^{k\,j}{}_{n\,m}$	. . .	1

4-C) Perform step 3 to determine the weights of the selected objective achieved using each alternative. Check pair wise comparison matrix consistency (table 4).

Table 4. Weights of objective j achieved by SC member k

	Objective $_j$
Alternative 1	$WA^{k}{}_{1j}$
. . .	. . .
Alternative $_I$	$WA^{k}{}_{ij}$
. . .	. . .
Alternative $_N$	$WA^{k}{}_{Nj}$

4-D) Weights are calculated for each of the objectives ($j=1\ldots n_k$) and then placed into the “weight matrix” (table 5).

Table 5. Weight matrix (SC member k)

	Objective $_1$	Objective n_k
Alternative 1	WA^k_{11}	$WE^k_{1\ nk}$
. . .	. . .	. . .
Alternative $_i$	WA^k_{i1}	$WE^k_{i\ nk}$
. . .	. . .	. . .
Alternative $_n$	WA^k_{n1}	$WE^k_{n\ nk1}$

Step 5. Weights from 4-C and 4-D are used to calculate the total scores for the alternatives under consideration. Alternative scores are calculated by multiplying weight matrix (4-D) by objective weights column (3-B).

$$AL_{ik} = \sum_{j=1}^{n_k} WE^k{}_{ij} \times W^k{}_i \quad i = 1 \ldots. n \qquad \text{(formula 7)}$$

k=1,2

The results are grouped into a matrix that contains the scores of supply chain members for the alternatives, as in table 6.

Table 6. Score matrix for SC alternatives

	SC-member 1	SC-member 2
Alternative 1	AL_{11}	AL_{12}
…..		
Alternative n	AL_{n1}	AL_{n2}

Step 6. The above methodology provides an analytically derived objective basis to select the optimum alternative to achieve goals established for both supply chain members. Once this objective assessment is made and a ranking established, supply chain members might then use subjective criteria, if they choose, to determine how best to achieve shared goals.

In this example, the alternative with the minimum squared error from the highest scores for each supply chain member was selected (alternative 1 in the algorithm described).

This selection process may be formulated as a nonlinear programming problem. A suggested approach to this problem formulation is described below:

Find $X_1 \ldots.. X_n$

To minimize

$$\sum_{i=1}^{n}(1-X_i)^2$$

subject to

$X_1 \ldots.. X_n$ - binary

$X_1+..+X_n = 1$

The selection process described above provides an objectively reached opportunity for mutual agreement on one of the alternatives available to chain members to reach system objectives. The scoring system provides each supply chain member with a specific level to measure the degree to which each objective is achieved using an agreed-upon alternative.

Step 7. Following the above process, the selected alternative may now be presented in terms of organizational activity performance. Supply chain members should make plans to integrate the selected alternative into the operational plan for the supply chain. The plan should also establish specified performance measurement and control systems to monitor progress on how well the system is performing to meet the agreed upon objectives. The selected joint action plan should be integrated with the operational plans of each supply chain member involved with this agreement. Intrasystem performance and control systems must satisfy all requirements imposed on them.

Application of the Pair Wise Comparison Matrix Technique

Example 1.

Step 1. A large agri-food processor and one of its supply chain partners–an overseas distributor–agreed in principle to introduce a new integrated information technology (IT) system.

There are three alternatives available to the two members for the introduction of a new IT system:

Alternative 1 - Purchase and install System X that is currently available;

Alternative 2 - Order a specialized system; or

Alternative 3 - Hire a group of specialists to develop a system and upgrade the system to meet all system requirements.

SCM-Member 1 (Agri-Food Producer)

Step 2-A. The agri-food producer has the following list of objectives to be achieved with the decision to introduce a new IT system:

- Minimize the net present value (NPV) of the required investment;
- Minimize business restructuring;
- Minimize documentation flow; and
- Maximize the number of employees “freed up” as a result of a new IT system.

Steps 3-A/5-A. Steps 3-5 are performed by the food producer. Table 7, is the result of steps 3-5. The table contains the scores for food processor decision alternatives, taking into account the objectives listed in step 2-A:

Table 7. Food processor scores for decision alternatives

	Priorities	Scores
Alternative 1	0.1238	3
Alternative 2	0.4988	1
Alternative 3	0.3776	2

SC-Member 2 (Distributor)

Step 2-A. The distributor has the following list of objectives to be achieved by the decision to implement a new IT system:

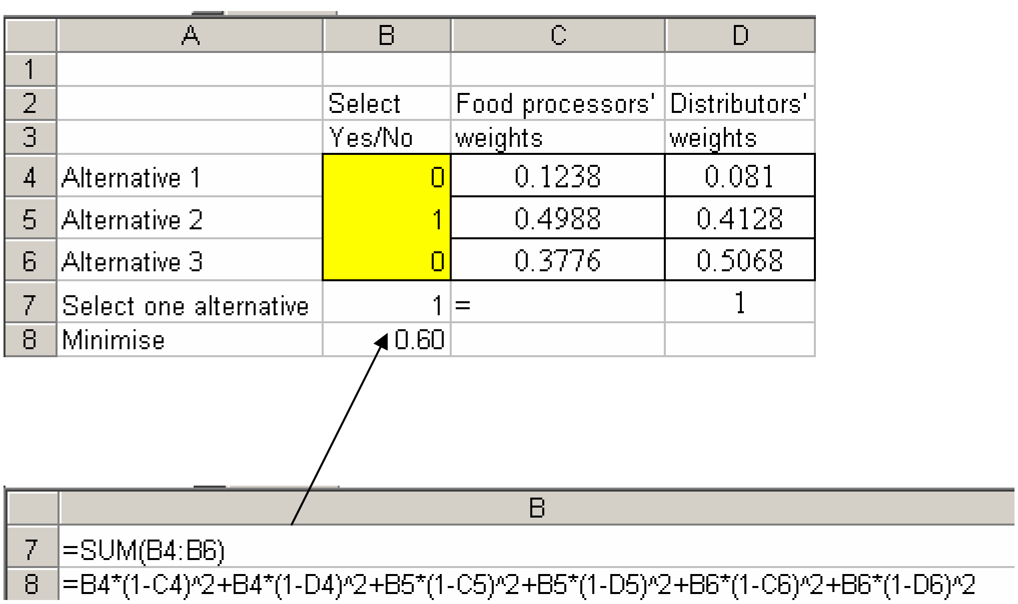
- Optimize customer database;
- Improve forecasting accuracy; and
- Minimize order fulfillment leadtime.

Steps 3-B/5-B. The distributor performs steps 3-5. Table 8 is the result of steps 3-5. The table contains the scores for distributor’s decision alternatives, taking into account the objectives listed in step 2-A. The following table represents scores for the distributor’s decision alternatives:

Table 8. Distributors' scores for decision alternatives

	Priorities	Scores
Alternative 1	**0.081**	**3**
Alternative 2	**0.4128**	**2**
Alternative 3	**0.5068**	**1**

Step 6. The priorities assigned to alternatives by the Food Processor and the Distributor, contained in tables 7 and 8, are combined. A Microsoft Excel worksheet (figure 14) was used to select the alternative with the lowest squared error from the highest weight for each supply chain member.



	A	B	C	D
1				
2		Select	Food processors'	Distributors'
3		Yes/No	weights	weights
4	Alternative 1	0	0.1238	0.081
5	Alternative 2	1	0.4988	0.4128
6	Alternative 3	0	0.3776	0.5068
7	Select one alternative	1	=	1
8	Minimise	0.60		

	B
7	=SUM(B4:B6)
8	=B4*(1-C4)^2+B4*(1-D4)^2+B5*(1-C5)^2+B5*(1-D5)^2+B6*(1-C6)^2+B6*(1-D6)^2

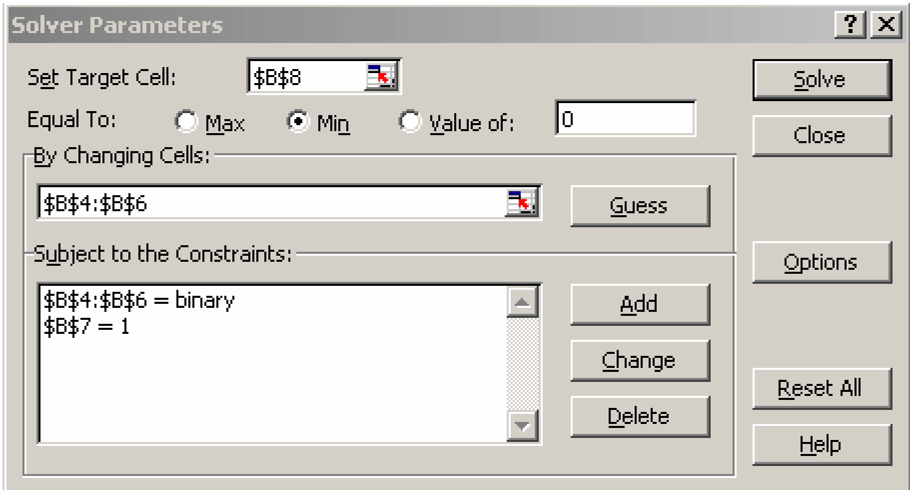


Figure 14. Microsoft Excel presentation of alternative selection

The optimum solution for this case study is to select the second alternative. In this case study, the optimum solution is obvious from the content of figure 14. However, in many joint action situations, there are more than two chain members involved.

An example of a decision that could affect many chain members could be a decision to modify container size or pallet loading. In such a situation, the alternative may be whether or not to change container size rather than attempting to select the optimum decision on alternative container sizes. A simple “yes” or “no” choice of alternatives–change container size or not–could have impacts on many chain members. These impacts could include items such as the number of people employed, whether or not purchasing new trucks would be required, if there would be an increase in documentation, or if modifications in ocean freight scheduling would be necessitated. All of these private actions would be affected by a joint action.

This research developed a methodology that quantitatively defines and measures the level of supply chain integration on an intracompany and intercompany basis. This is achieved through a structured search for alternatives. The methodology selects the alternative that is optimal for all parties involved. The selection process, solved using an objective criterion, may be modified to meet intrafirm and interfirm subjective criteria.

Example 2

A second example of an analytical technique a firm may use to improve its supply chain performance follows.

A dairy company produces milk powder at three plants. Milk powder is shipped to five different seaports. The costs of production and transportation of milk powder from each plant to each seaport are given in table 9.

Table 9. Transportation costs ($/MT)

From/to	Seaport 1	Seaport 2	Seaport 3	Seaport 4	Seaport 5
Plant 1	27.86	4.00	20.54	21.52	13.87
Plant 2	8.02	20.54	2.00	6.74	10.67
Plant 3	2.00	27.86	8.02	8.41	15.20

Note: MT=metric ton

The seaports specialize in exporting milk powder to different overseas markets. The following demand forecasts for the next year are obtained.

Table 10. Demand (MT/year)

Market 1 - Seaport 1	Market 2 - Seaport 2	Market 3 - Seaport 3	Market 4 - Seaport 4	Market 5 - Seaport 5
55,000	50,000	60,000	60,000	45,000

The question the firm must answer is which plant-seaport-market combination results in the lowest cost distribution result. While this may appear to be a private action decision–a decision that affects only one company–the decision affects several members of a supply chain. Port companies, shipping lines, and domestic carriers are all affected by the decision. For those firms to operate efficiently, they must be aware of–and perhaps participate in–decisions about port selection.

Step 1. Identify the decision variables.

A decision needs to be made on how many metric tons (MT) of milk powder to ship from each plant to each seaport.

Let X(i,j) denote a number of MT of milk powder to be shipped from plant i (i=1..3) to seaport j(1,…,5) (table 11).

Table 11. Metric tons to be shipped from plant

From/to	Seaport 1	Seaport 2	Seaport 3	Seaport 4	Seaport 5
Plant 1	X(1,1)	X(1,2)	X(1,3)	X(1,4)	X(1,5)
Plant 2	X(2,1)	X(2,2)	X(2,3)	X(2,4)	X(2,5)
Plant 3	X(3,1)	X(3,2)	X(3,3)	X(3,4)	X(3,5)

Step 2. Present data available.

a) Transportation costs are presented in table 9.

Let C(i,j) denote the transportation cost to move one MT of milk powder from plant i (i=1..3) to seaport j(1,…,5).

b) Demand constraints are presented in table 10.

Let D(j) denote demand for milk powder in export market j(1,…,5).

c) Capacity constraints are 100,000 MT for each plant.

Let S(j) denote capacity limits for milk powder in plant i (i=1..3).

Data may be grouped together as presented in table 12.

Table 12. Data presentation

From/to	Seaport 1	Seaport 2	Seaport 3	Seaport 4	Seaport 5	Dummy	Capacity
Plant 1	27.86	4.00	20.54	21.52	13.87	0.00	100,000
Plant 2	8.02	20.54	2.00	6.74	10.67	0.00	100,000
Plant 3	2.00	27.86	8.02	8.41	15.20	0.00	100,000
Demand	55,000	50,000	60,000	60,000	45,000	30,000	

Note: This problem is unbalanced (total capacity exceeds total demand for 30,000 MT). To balance this situation, a "dummy demand" point with zero transportation costs and demand of 30,000 MT was introduced. New variables X(1,6), X(1,7), and X(1,8) were also added.

Step 3. Define the objective function.

The objective function is the total transportation cost distribution policy:

$$\sum_{i=1}^{3}\sum_{j=1}^{6} X(i,j)C(i,j)$$

Step 4. Define constraints.

a) Demand constraints.

Products transported from all three plants to any seaport should satisfy demand requirements:

$$\sum_{i=1}^{3}(X(i,j) \geq D(j)$$

j=1,…6

b) Capacity constraints.

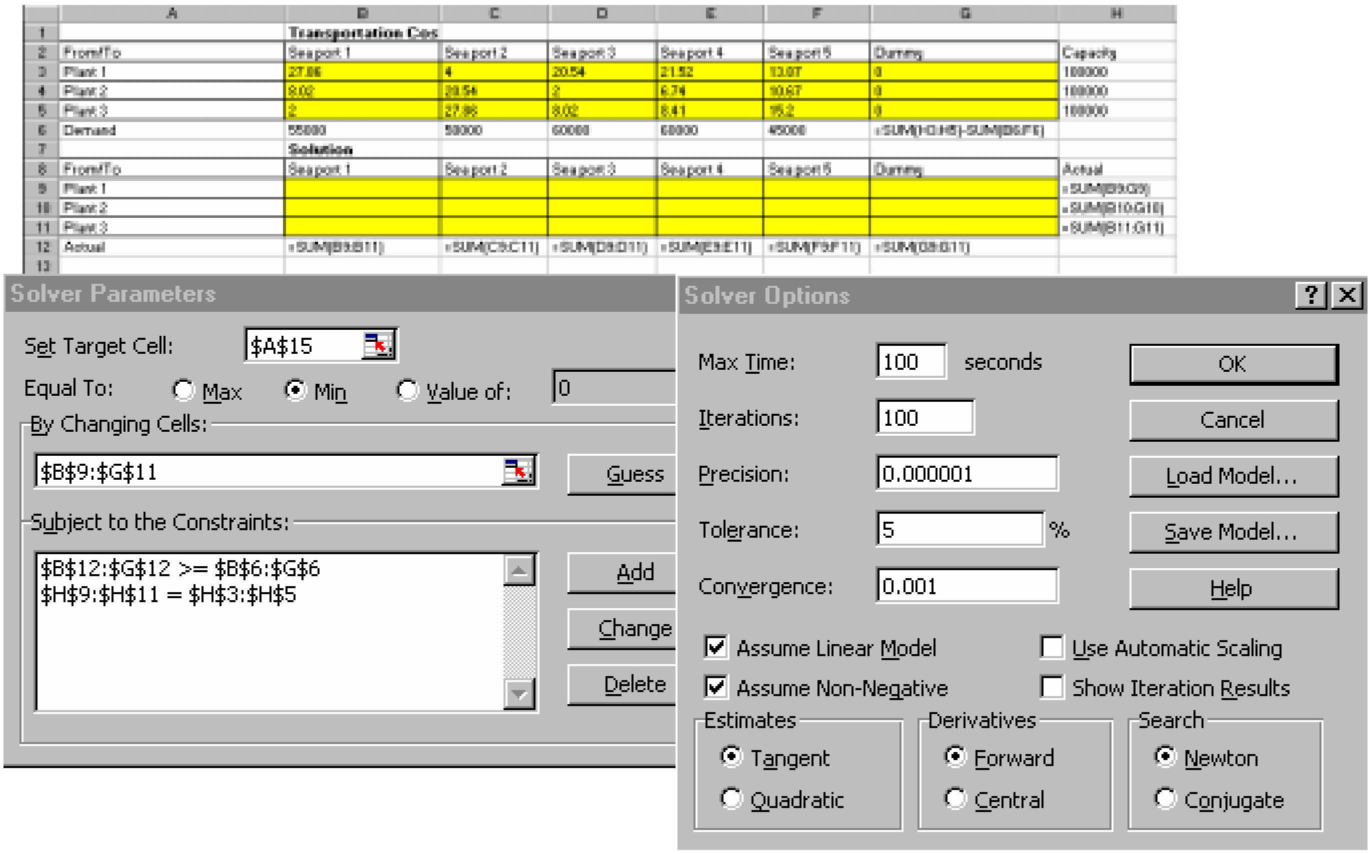
Production shipped from each plant to all six destinations should equal plants' maximum capacity:

$$\sum_{j=1}^{6} X(i,j) = S(i)$$

i=1,…,3

Step 5. Select software.

Microsoft Solver was used. The problem is in the following form:



1		Transportation Costs						
2	From/To	Sea port 1	Sea port 2	Sea port 3	Sea port 4	Sea port 5	Dummy	Capacity
3	Plant 1	27.86	4.00	20.54	21.52	13.87	0.00	100,000
4	Plant 2	8.02	20.54	2.00	6.74	10.67	0.00	100,000
5	Plant 3	2.00	27.86	8.02	8.41	15.20	0.00	100,000
6	Demand	55,000	50,000	60,000	60,000	45,000	30,000	
7		Solution						
8	From/To	Sea port 1	Sea port 2	Sea port 3	Sea port 4	Sea port 5	Dummy	Actual
9	Plant 1							-
10	Plant 2							-
11	Plant 3							-
12	Actual	-	-	-	-	-	-	
13								
14	Total Transportation Costs							
15	-							

Figure 15. An example using Microsoft Solver software

Step 6. Debug the model.

To debug the model, enter any feasible distribution policy into the solution range and check to ensure that total transportation cost and the left sides of all the constraints have correct values. For example:

Table 13. Debugging the model

	Solution						
From/to	Seaport 1	Seaport 2	Seaport 3	Seaport 4	Seaport 5	Dummy	Actual
Plant 1		50,000		5,000	45,000		100,000
Plant 2			60,000	40,000			100,000
Plant 3	55,000			15,000		30,000	100,000
Actual	55,000	50,000	60,000	60,000	45,000	30,000	

Step 7. Solve the problem.

Check all Microsoft Solver dialog boxes and press <Solve>.

Solver Results window will appear. Mark in the window on the right side "Answer" and "Sensitivity" reports and press <OK>.

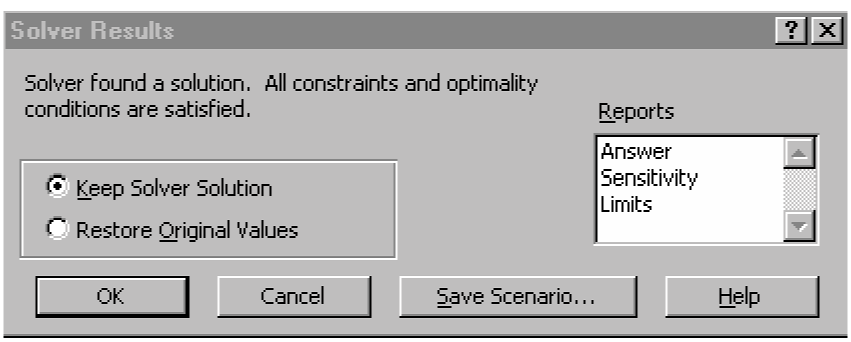


Figure 16. Using Microsoft Solver to solve the problem

An optimum solution will be:

	Solution						
From/To	Sea port 1	Sea port 2	Sea port 3	Sea port 4	Sea port 5	Dummy	Actual
Plant 1	-	50,000	-	-	20,000	30,000	100,000
Plant 2	-	-	60,000	15,000	25,000	-	100,000
Plant 3	55,000	-	-	45,000	-	-	100,000
Actual	55,000	50,000	60,000	60,000	45,000	30,000	
Total Transportation Costs							
1,453,700							

Figure 17. Microsoft Solver provides optimum solution

Step 8. Analyze results.

Table 14. Microsoft Excel 8.0 sensitivity report

Adjustable cells

Cell	Name	Final value	Reduced cost	Objective coefficient	Allowable increase	Allowable decrease
B9	Plant 1-Seaport 1	-	24	27.86	1E+30	24.33
C9	Plant 1-Seaport 2	50,000	-	4	19.74	4
D9	Plant 1-Seaport 3	-	15	20.54	1E+30	15.34
E9	Plant 1-Seaport 4	-	12	21.52	1E+30	11.58
F9	Plant 1-Seaport 5	20,000	-	13.87	11.58	1.53
G9	Plant 1-Dummy	30,000	-	0	1.53	1E+30
B10	Plant 2-Seaport 1	-	8	8.02	1E+30	7.69
C10	Plant 2-Seaport 2	-	20	20.54	1E+30	19.74
D10	Plant 2-Seaport 3	60,000	-	2	4.35	5.2
E10	Plant 2-Seaport 4	15,000	-	6.74	7.69	1.53
F10	Plant 2-Seaport 5	25,000	-	10.67	1.53	11.58
G10	Plant 2-Dummy	-	3	0	1E+30	3.2
B11	Plant 3-Seaport 1	55,000	-	2	7.69	3.53
C11	Plant 3-Seaport 2	-	25	27.86	1E+30	25.39
D11	Plant 3-Seaport 3	-	4	8.02	1E+30	4.35
E11	Plant 3-Seaport 4	45,000	-	8.41	1.53	7.69
F11	Plant 3-Seaport 5	-	3	15.2	1E+30	2.86
G11	Plant 3-Dummy	-	2	0	1E+30	1.53

Constraints

Cell	Name	Final value	Shadow price	Constraint R.H. side	Allowable increase	Allowable decrease
B12	Actual Seaport 1	55,000	4	55000	0	15000

C12	Actual Seaport 2	50,000		4	50000	0	50000
D12	Actual Seaport 3	60,000		5	60000	0	20000
E12	Actual Seaport 4	60,000		10	60000	0	15000
F12	Actual Seaport 5	45,000		14	45000	0	20000
G12	Actual Dummy	30,000		-	30000	0	1E+30
H9	Plant 1 Actual	100,000		-	100000	1E+30	0
H10	Plant 2 Actual	100,000	-	3	100000	20000	0
H11	Plant 3 Actual	100,000	-	2	100000	15000	0

Summary

It is believed that the majority of agricultural exporters do not use SCM. Although there may be number of reasons for this, two important reasons are costs and risk. This chapter provided two examples that a firm might use to improve the performance of the supply chain while minimizing both cost and risk.

The first technique examined how firms may arrive at a decision that improves system performance despite potentially conflicting goals. Such a technique recognizes the importance of chain members to mutually solve problems. This technique is designed to achieve an optimum decision when the two firms involved in that decision have similar shared interests but different and, potentially conflicting, private interests.

The example discussed chain conflicts that might arise over the purchase of new information technology. A food exporter may seek to minimize the net present value of the required investment, minimize business restructuring, minimize documentation flow, and maximize the number of employees “freed up” as a result of a new IT system. The export distribution firm used may seek to optimize its customer database, improve forecasting accuracy, and/or minimize order fulfillment leadtime. The example establishes a methodology to solve the conflicts of chain participants yet arrive at a solution that improves the performance of all supply chain members.

The chapter contains a second example of a method to improve supply chain performance. This example provides a model by which a company may make internal decisions about transportation that may significantly reduce costs. The decisions focus on port selection. Production, originating from several production facilities, may be exported through different ports. The model determines which port to use and how much product to export through the port to minimize distribution costs to three export markets.

Although these decisions are internally generated, with transportation cost reductions the driving factor behind the model, the example explains how a company may improve its efficiency, reduce costs, and potentially improve customer service. Consequently, this decision has ramifications throughout the supply chain. Port selection, for example, affects many different chain participants. So, while the decision may be made internally, the joint consequences of the decision must be recognized.

The examples discussed in chapter five focus on techniques firms may use to improve their performance and enhance their competitive ability without relying on price reductions to remain competitive.

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